Breakthrough in air purification with a catalyst that works at room temperature

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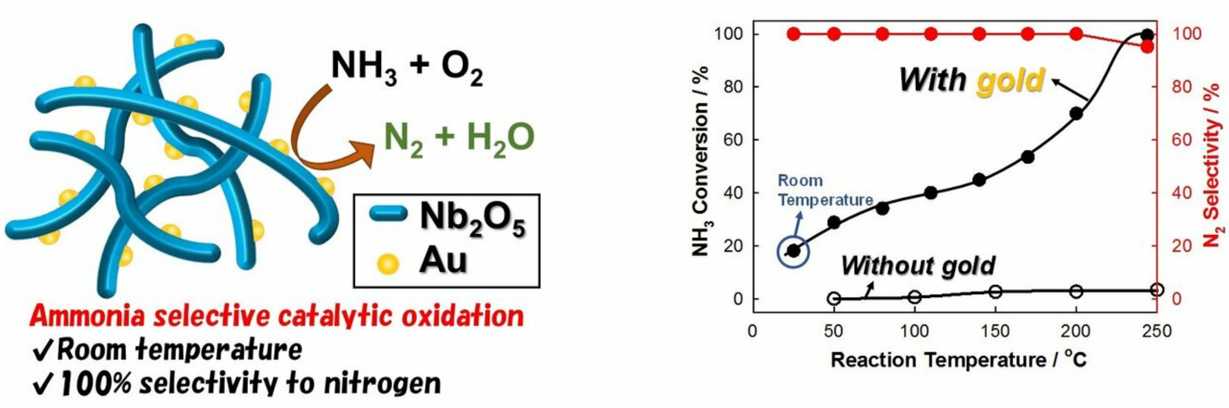

(left) Simplified schematic of gold nanoparticles attached to a niobium oxide framework. (right) Conversion efficiency of filter with and without gold, plus selectivity for conversion to nitrogen and water. The graph shows that frameworks loaded with gold nanoparticles show vastly improved activity at room temperature, with excellent selectivity over the entire temperature range. Credit: Toru Murayama

Researchers from Tokyo Metropolitan University report that a newly engineered catalyst made of gold nanoparticles supported on a metal oxide framework shows breakdown of ammonia impurities in air, with excellent selectivity for conversion to nitrogen gas. Importantly, it is effective at room temperature, making it suitable for everyday air purification systems. The team successfully identified the mechanism behind this behavior, paving the way toward the design of other novel catalytic materials.

Ammonia is a common industrial chemical, primarily used as feedstock for fertilizers as well as disinfectants in both household and medical settings. It is also highly toxic when concentrated; the United States Occupational Safety and Hazard Administration has a strict upper limit of 50 parts per million in breathing air averaged over an eight-hour working day and forty-hour working week. Given its wide industrial use and presence in nature, it is paramount that effective measures be in place to remove unwanted ammonia from the atmosphere in everyday working and living environments.

Catalysts, like those found in the catalytic converters of cars, can help solve this problem. Unlike filters that simply trap harmful substances, catalytic filters can help break ammonia down into harmless products like nitrogen gas and water. Not only is it safer, preventing the buildup of toxic chemicals, it also makes it unnecessary to replace them regularly. However, common existing catalysts for ammonia only function at temperatures of over 200 degrees Celsius, making them inefficient as well as inapplicable for household settings.

Now, a team led by Project Professor Toru Murayama from Tokyo Metropolitan University has designed a catalytic filter that can function at room temperature. Consisting of gold nanoparticles stuck onto a framework of niobium oxide, the newly designed filter is highly selective in what it converts ammonia to, with nearly all conversion to harmless nitrogen gas and water and no nitrogen oxide byproducts. This is known as selective catalytic oxidation (SCO). They collaborated with industrial partners from NBC Meshtec Inc. to produce a working prototype; the filter has already been applied to reduce gases contaminated with ammonia to undetectable levels.

Importantly, the team also successfully uncovered the mechanism by which the material works. They showed that gold nanoparticles play an important role, with increased loading leading to increased catalytic activity; they also found that the choice of framework was extremely important, showing experimentally that chemical sites known as Brønsted acid sites on the niobium oxide backbone played an important role in how selective the material was. The team hopes that general design principles like this may find application to the creation and modification of other catalytic materials, extending their growing range of applications.

More information: Mingyue Lin et al, Role of the Acid Site for Selective Catalytic Oxidation of NH_3 over Au/Nb_2O_5, *ACS Catalysis* (2019). DOI: 10.1021/acscatal.8b04272

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